Complementary Programs

The LWS program, with its dual focus on space weather research and applications, is complemented by two other programs described herein. These are the existing NASA Solar Terrestrial Probes (STP) program and the multi-agency Space Environment Testbed (SET) initiative.

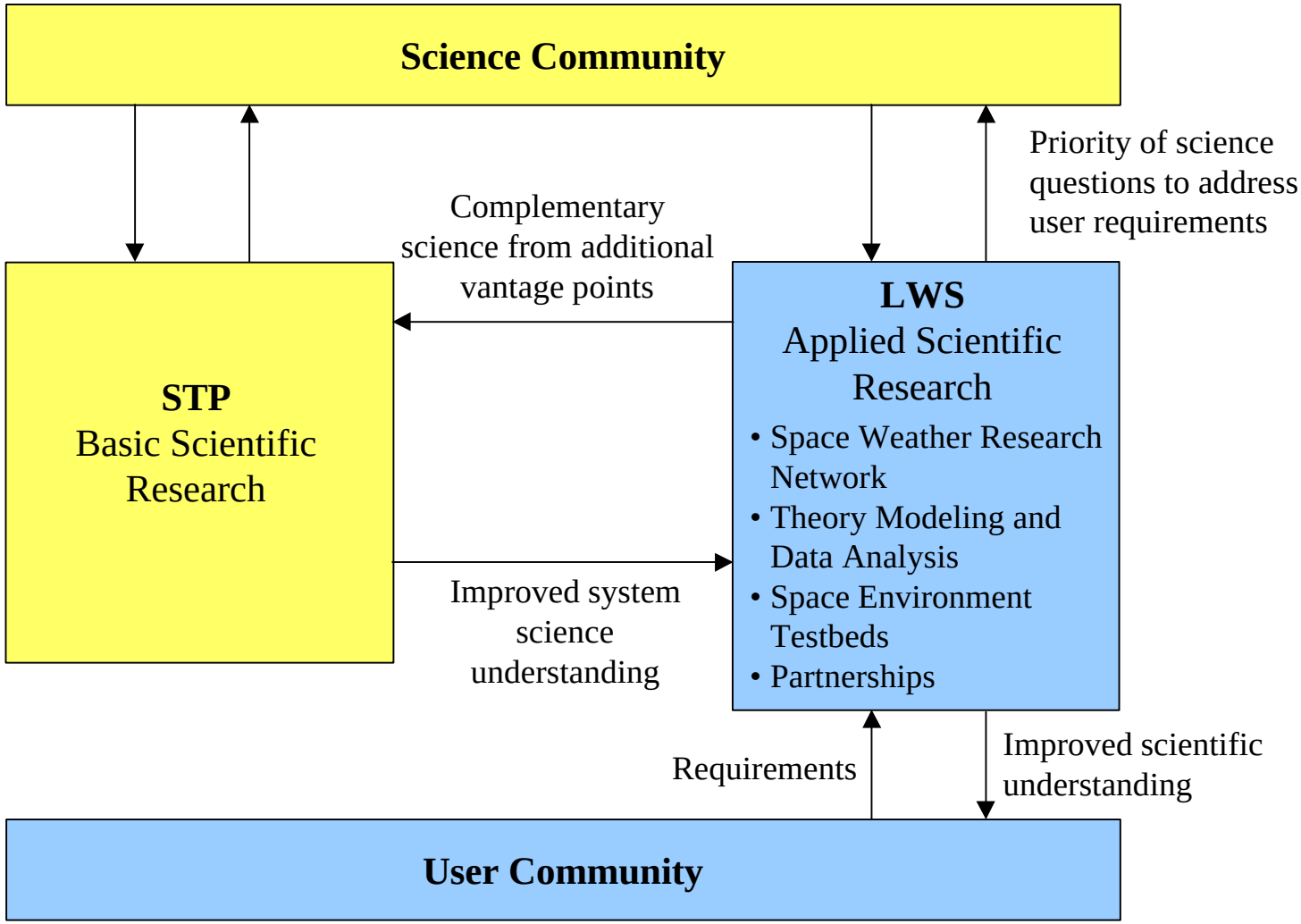
The STP program consists of a strategic line of synergistic science missions as identified in the SEC science roadmap and the OSS strategic plan. Future STP missions include Solar-B, STEREO, Magnetospheric Multiscale (MMS), Geospace Electrodynamics Connections (GEC), and the Magnetospheric Constellation (MagCon). Budget augmentations to the STP program are being sought by the SEC Program Director so that intervals between successive launches could be reduced to approximately 18 months. Such a cadence or frequency would allow scientific findings from these separately-funded STP missions to influence and enhance the LWS science and applications program that spans the time interval from 2001 until 2012.

Complementary Programs (cont.)

The SET initiative, funded partially from the LWS program, has as its primary objective mitigation of radiation effects on a broad range of parts, circuitry, and components that are used frequently in building space flight systems.

The relationship of STP and LWS are illustrated in the block diagram on the following page.

Program Relationships



Supporting Science

•The science objectives and missions described in the other sections of this implementation plan address the primary needs to achieve the LWS goals. However, there are additional science goals which have been determined to be important supplements to LWS science. They were omitted from the LWS preformulation plan for several possible reasons:

- the science is currently part of another planned program
- resources required were too costly or otherwise difficult to accommodate within the current LWS plan
- the science was identified as critical to LWS but requires further consideration and definition beyond this preformulation study
- the science would not directly enhance our understanding of space weather and the impact on humans, but could provide vital information about certain aspects of physics and astronomy
- the science is not developed enough to show definite promise as a tool for understanding the space environment, but may become essential in the future

•The supporting science topics discussed in this section will enhance the impact of the LWS program and would contribute directly to its success. The omission of any of these aspects should be considered closely by future studies.

LWS Supporting Science: Integration into the SEC Roadmap

The items on the Sun-Earth Connection Roadmap were identified by the scientific community by considering the science which is crucial to the continued success of the SEC theme. All of the LWS missions appear in some form as a mission or a combination of missions on the Sun-Earth Connection Roadmap. However, there were modifications made to these Roadmap items in response to the specific requirements and extent of the LWS program. Therefore, consideration may need to be given to the aspects of the SEC Roadmap which may have been "orphaned" in this process.

• EUV Spectroscopy originally appeared on the Sun-Earth Connections Roadmap under the “SONAR” mission platform. Solar Dynamics

Spectroscopy allows us to determine the temperature, velocity and composition of solar features; without the continuation of spectroscopic

• Further studies must be undertaken to determine the regimes in irradiance

during the preliminary definition phase, but will play a major role in connecting Sun-Earth energy flow.

• Recent studies have indicated that cosmic ray flux plays a role in geospace weather determination. Further investigation is required to determine whether cosmic ray studies will be pivotal to the LWS program.

• It is anticipated that soft X-ray imaging and flux monitoring will be provided

High-Energy Flare Mission for LWS

Objectives

- To understand the role that high-energy flares play in the origin of geo-effective events.
- To understand the underlying plasma physics of geo-effective events through study of high-energy manifestations of magnetic energy conversion at the Sun.
- To understand the production of flare-generated radiation and particles that affect the Earth and the space environment.

Background

- There is great benefit to having a high-energy flare mission similar to PASO coordinated with LWS observations during the next solar maximum.
- To understand geoeffective events, we need to understand the relationship between CMEs and flares. They tend to occur together and the energy that drives them both is believed to come from rapid changes in the solar magnetic field.
- Hard X-ray spectral hardening in a flare may provide a warning of an impending large particle event at Earth.

Questions

- What processes take place during explosive energy release when a CME lifts off and an associated flare occurs?
- How is magnetic energy transferred to energetic particles, heat, and mass motion during the sequence of events that results in a flare and a CME?
- What determines the variable partitioning of energy among these products?

High-Energy Flare Mission for LWS

Plan of Action

- Conduct high-energy flare observations during Solar Cycle 24 peaking in ~2011.
- Obtain high-resolution imaging spectroscopy of flare X-rays and gamma rays.
- Coordinate with simultaneous flare, CME, and active region observations from other spacecraft and ground-based observatories. These include radio, optical, UV, coronagraph, magnetograph, and particle measurements.

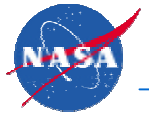
Measurements

- Hard X-ray imaging spectroscopy at energies from <10 to >500 keV with ~1 arc second angular resolution, ~2 keV energy resolution, and ~10 ms time resolution, and with capability for ~1% polarization measurements.
- Gamma-ray imaging spectroscopy at energies from <0.5 to >10 MeV with 10 arc second angular resolution, ~4 keV energy resolution, and ~ 1 s time resolution.
- Gamma ray and neutron spectroscopy from MeV to GeV energies with ~15% energy resolution.

LWS Supporting Science: Heliosphere

• A “solar wind monitor” is required to provide the input function for the magnetospheric/ionospheric elements for both the scientific and the user communities. An L1 option has been studied as part of the Sentinels, but not priced in our current plan. This monitor would provide a key point of observation in the IHS cluster.

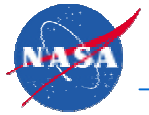
• Energetic particles over 100 MeV were not included in the Sentinels preformulation study. It is currently believed that observation of the highest energy particles holds the promise of developing an understanding of their acceleration mechanism, hence a capability to predict rather than simply monitor the 20-100 MeV particles, which are considered the most dangerous. Such an instrument is way too heavy to be placed on any of the Sentinel spacecraft in the current preformulation plan. A possible option is to place this kind of instrument on the International Space Station.



LWS Supporting Science: Radiation Belt Mappers

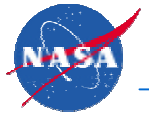
•The RBM preformulation study team noted the desirability of thermal plasma measurements of the Earth's plasmasphere. Determination of plasmasphere boundaries, total ion densities, temperatures, and 2D structure were identified as highly desirable parameters for predictive capabilities. Operationally, thermal plasma effects on spacecraft charging and satellite-to-satellite communication (total electron content along the line of site) are of interest. Detailed distribution characterization throughout the plasmasphere and trough was deemed outside the scope of the primary science objectives for RBM as were the outstanding questions regarding the importance of thermal plasma contributions to storm dynamics.

• The RBM preformulation study team recognized that the 7-12 Re altitude range is an important plasma source region for the radiation belts. Knowledge of plasma flow and energetics from this transition region between adiabatic and nonadiabatic behavior beyond the RBM geosynchronous orbit distances is required for the accomplishment of the science. For example, causes of substorms are not within the RBM science objectives, however, the effects of substorm injections such as their contribution to spacecraft surface charging events is of interest. RBM assumes that non-LWS missions, such as Magnetosphere Constellation, Inner Magnetosphere Constellation and the various geosynchronously orbiting spacecraft, will provide the required data in the time frame of the RBM mission.



LWS Supporting Science: Radiation Belt Mappers (cont.)

- Missions prior to RBM and IM, such as IMAGE and Twins, will prove the feasibility of monitoring the state of the magnetosphere by auroral imaging, EUV imaging and ENA imaging. However, both missions will end before the RBM and IM missions are flown. LWS science can greatly benefit with continuous monitoring of the state of the magnetosphere to place into context the in-situ measurements from the RBM and IT spacecraft and measurements of the global response of geospace to solar events and the passage of solar plasma through the heliosphere. Due to the properties of polar orbits for satellites, two common imaging spacecraft with apogees phased 90 degrees in latitude would be required for almost continuous monitoring, though one spacecraft would be most useful. The cost of this supplementary program is beyond the scope of LWS.



Measurements Requiring Innovative Approaches For Development Under LWS

Measurement Requirement:

- Solar wind data from L1 - included in Sentinels discussion but not costed
- Upper atmosphere remote sensing
- Low latitude ionosphere
- High energy galactic cosmic rays (E > 100 Mev)

Possible Sources:

- Existing asset (WIND, Triana, etc)
- Partnership
- Partnership/Mission of Opportunity
- Partnership/Mission of Opportunity
- Ground-based neutron monitors or dedicated high energy cosmic ray instruments to be flown on ISS